

DOT POINT

VISIT...

IB PHYSICS CORE



hargava



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What the book includes

This book provides questions and answers for each dot point in the IB Physics Core syllabus from the International Baccalaureate Diploma Programme for Physics:

- Physics and Physical Measurement
- Mechanics
- Thermal Physics
- Oscillations and Waves
- Electric Currents
- Fields and Forces
- Atomic and Nuclear Physics
- Energy, Power and Climate Change

Format of the book

The book has been formatted in the following way:

1.1 Subtopic from syllabus.

1.1.1 Assessment statement from syllabus.

1.1.1.1 First question for this assessment statement.

1.1.1.2 Second question for this assessment statement.

The number of lines provided for each answer gives an indication of how many marks the question might be worth in an examination. As a rough rule, every two lines of answer might be worth 1 mark.

How to use the book

Completing all questions will provide you with a summary of all the work you need to know from the syllabus. You may have done work in addition to this with your teacher as extension work. Obviously this is not covered, but you may need to know this additional work for your school exams.

When working through the questions, write the answers you have to look up in a different colour to those you know without having to research the work. This will provide you with a quick reference for work needing further revision.

Command Terms and Verbs to Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Use an idea, equation, principle, theory or law in a new situation.

assess Make a judgement of value, quality, outcomes, results or size.

calculate Find a numerical answer showing the relevant stages in the working (unless instructed not to do so).

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Give an account of similarities and differences between two (or more) items, referring to both (all) of them throughout.

construct Represent or develop in graphical form.

contrast Show how things are different or opposite.

deduce Reach a conclusion from the information given.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Give an account including, where possible, a range of arguments for and against the relative importance of various factors, or comparisons of alternative hypotheses.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Give a detailed account of causes, reasons or mechanisms.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

identify Find an answer from a given number of possibilities.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers with no explanation.

measure Find a value for a quantity.

outline Give a brief account or summary.

predict Give an expected result.

propose Put forward a point of view, idea, argument, suggestion etc for consideration or action.

recall Present remembered ideas, facts or experiences.

show Give the steps in a calculation or derivation.

sketch Represent by means of a graph showing a line and labelled but unscaled axes but with important features (for example, intercept) clearly indicated.

solve Obtain an answer using algebraic and/or numerical methods.

state Give a specific name, value or other brief answer without explanation or calculation.

suggest Propose a hypothesis or other possible answer.

summarise Express concisely the relevant details.

synthesise Put together various elements to make a whole.

Physics and Physical Measurement

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CORE 1

Physics and Physical Measurement

Notes

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1.1 The realm of physics. © IBO 2007

Range of magnitudes of quantities in our Universe

1.1.1 State and compare quantities to the nearest order of magnitude. © IBO 2007

1.1.1.1 Define what is meant by 'order of magnitude'.

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1.1.1.2 Give the order of magnitude of the numbers in the table.

	Number	Order of magnitude		Number	Order of magnitude
(a)	6.0		(k)	12 678 945	
(b)	0.004		(l)	56 743	
(c)	13		(m)	−578	
(d)	0.02		(n)	−0.0000003	
(e)	156		(o)	1 234 567 890	
(f)	6789		(p)	9 876 543 210	
(g)	42		(q)	449	
(h)	0.78		(r)	3150	
(i)	0.00003		(s)	3200	
(j)	0.00007		(t)	0.008	

1.1.1.3 Discuss when it is appropriate to use orders of magnitudes in answers and when it is appropriate to give exact answers.

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1.1.2 State the ranges of magnitude of distances, masses and times that occur in the Universe from smallest to greatest. © IBO 2007

1.1.2.1 Complete the following tables to show the orders of magnitude of distances, masses and times in the Universe.

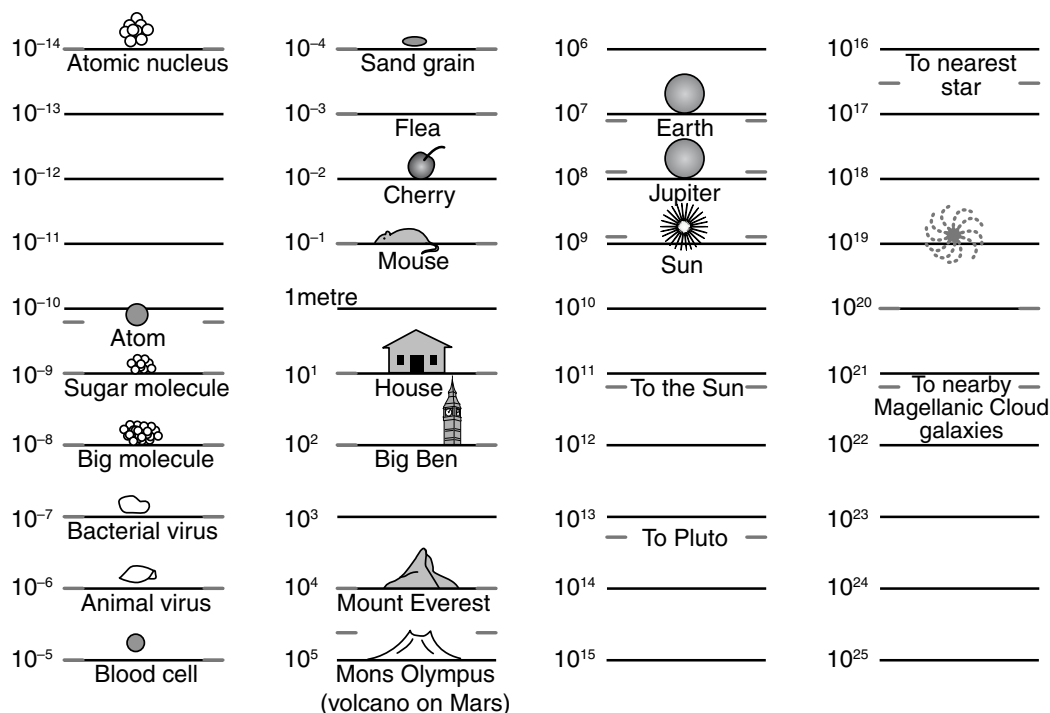
	Mass in kg	Order of magnitude of quantity
(a)	Mass of the Universe	
(b)	Mass of the Earth	
(c)	Average mass of a car	
(d)	Mass of a tennis ball	
(e)	Mass of a fly	
(f)	Mass of a hydrogen atom	
(g)	Mass of an electron	

	Distance in km	Order of magnitude of quantity
(h)	Size of visible Universe	
(i)	Distance to nearest star (Proxima Centauri)	
(j)	Distance to the Sun	
(k)	Diameter of the Earth	
(l)	Height of average person	
(m)	Thickness of a spider web strand	
(n)	Diameter of an atom	

	Time in seconds	Order of magnitude of quantity
(o)	Age of the Universe	
(p)	Time since dinosaurs were on Earth	
(q)	Human life span	
(r)	One year	
(s)	One day	
(t)	Time a meson 'lives'	
(u)	Period of visible light	

1.1.3 State ratios of quantities as differences of orders of magnitude. © IBO 2007

1.1.3.1 The information shows the order of magnitude of the size of various objects in the Universe. Use it to answer this question.



According to this data (express answers in orders of magnitude):

- How much larger is an atom than an atomic nucleus?
- How much larger is a blood cell than a bacterial virus?
- How much larger is a grain of sand than a blood cell?
- How much larger is a cherry than a grain of sand?
- How much larger is a mouse than an atom?
- How much larger is a house than a mouse?
- How much larger is Mount Everest than a house?
- How much larger is the Earth than an atomic nucleus?
- How much larger is the Earth than a house?
- Compare the distance to the Sun with that to Pluto.
- Compare the distance to the Sun to that to the nearest star.
- Compare the size of the Earth to that of the galaxy.

1.1.4 Estimate approximate values of everyday quantities to one or two significant figures and/or to the nearest order of magnitude. © IBO 2007

1.1.4.1 Estimate the size of each of the following to two significant figures and express each estimate to the nearest order of magnitude. DO NOT use a calculator on mathematical examples!

	Object	Estimate in appropriate unit	Nearest order of magnitude	Tick if you were 'close'
(a)	Length of your arm in cm.			
(b)	Width of a page of this book in mm.			
(c)	Mass of an orange in grams.			
(d)	$6.67 \times 10^{-11} \times 5.974 \times 10^{24} \times 3 \times 10^5 \div (4.2 \times 10^7)$			
(e)	Volume of a coffee mug.			
(f)	Volume of a bucket.			
(g)	Volume of a grain of rice.			
(h)	Number of grains of rice in a cup.			
(i)	Dimensions of a typical calculator.			
(j)	Molecules of water in a full teacup.			
(k)	$\sqrt{(100^2 - 75^2/100^2)}$			
(l)	Diameter of a basketball.			
(m)	Height of a can of soft drink.			
(n)	Mass of a loaf of bread.			
(o)	$(42\,380\,000)^3/(86\,400)^2$			
(p)	$3 \times 10^{21} \div 1.5 \times 10^{12}$			
(q)	Mass of a can of soft drink.			
(r)	Distance between Earth and the Moon.			
(s)	Volume of the Earth.			
(t)	$9 \times 10^9 \times 2.5 \times 10^{-8} \times 4.0 \times 10^{-8} \div 0.5^2$			

1.2 Measurement and uncertainties. © IBO 2007

The SI system of fundamental and derived units

1.2.1 State the fundamental units in the SI system. © IBO 2007

1.2.2 Distinguish between fundamental and derived units and give examples of derived units. © IBO 2007

Note that 1.2.1 and 1.2.2 are combined and questions carry 1.2.1 numbers.

1.2.1.1 Define a fundamental quantity.

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1.2.1.2 Giving examples if needed, clarify the concept of a derived quantity.

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1.2.1.3 Using density as your example, explain the difference between a fundamental unit and a derived unit.

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1.2.1.4 What is an SI unit and why are they used?

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1.2.1.5 Complete the table to show the seven fundamental quantities and their units.

	Fundamental quantity	SI unit for quantity	SI symbol for unit
(a)			
(b)			
(c)			
(d)			
(e)			
(f)			
(g)			

1.2.1.6 Complete the table to show derived quantities and their units.

	Derived quantity	SI unit for quantity	SI symbol for unit	Dependence on fundamental units
(a)	Acceleration			
(b)	Charge			
(c)	Electric field strength			
(d)	Electrical potential			
(e)	Electrical resistance			
(f)	Energy			
(g)	Force			
(h)	Frequency			
(i)	Heat capacity			
(j)	Magnetic field strength			
(k)	Magnetic flux			
(l)	Momentum			
(m)	Power			
(n)	Pressure			
(o)	Radioactivity			
(p)	Specific heat capacity			
(q)	Velocity			

1.2.1.7 Which of the following contains only fundamental SI units?

- (A) Coulomb, kilogram, second.
- (B) Kelvin, ohm, second.
- (C) Ampere, kilogram, mole.
- (D) Kilogram, metre, weber.

1.2.1.8 Which of the following contains a unit which is not fundamental?

- (A) Ampere, kilogram, second.
- (B) Candela, mole, joule.
- (C) Ampere, kelvin, metre.
- (D) Kilogram, metre, candela.

1.2.3 Convert between different units of quantities. © IBO 2007

1.2.4 State units in the accepted SI format. © IBO 2007

1.2.5 State values in scientific notation and multiples of units with appropriate prefixes. © IBO 2007

Note that 1.2.3, 1.2.4 and 1.2.5 are combined and questions carry 1.2.3 numbers.

1.2.3.1 Complete the table to summarise the meaning of the various prefixes used with units.

Multiple	Prefix	Symbol
10^{24}		
10^{21}		
10^{18}		
10^{15}		
		T
		G
		M
		k
	Hecto	
	Deca	

Multiple	Prefix	Symbol
	Deci	
	Centi	
10^{-3}		
10^{-6}		
		n
		p
	Femto	
	Atto	
10^{-21}		
10^{-24}		

Use the information in your completed table to help you answer the following questions.

1.2.3.2 Convert each of the following to fundamental SI units.

- (a) 720 g
- (b) 4.5 tonnes
- (c) 1056 nm
- (d) 4.5 light years
- (e) 2.4 AU (astronomical units)

1.2.3.3 Convert the following to SI units.

- (a) 28 000 kph
- (b) 45 cm^3
- (c) 400 kPa
- (d) 3000 GL
- (e) 2.5 MJ

1.2.3.4 Calculate the distance travelled by a car which is travelling at 30 kph for 45 minutes. Express your answer in SI units.

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- 1.2.3.5** Kepler's law of periods for the motion of planets around the Sun, where r is the orbital radius of a planet, M the mass of the Sun, T the time it takes the planet to orbit the Sun and G is the universal gravitational constant, can be represented by the equation:

$$\frac{r^3}{T^2} = \frac{GM_{\text{Sun}}}{4\pi^2}$$

Determine the SI unit for G .

- 1.2.3.6** A typical household will have an average of five lights on for about 6 hours each day during the year. If each light globe is rated at 60 W of electrical power, calculate the energy consumed by these lights during the year. Give your answer in the most appropriate form.

- 1.2.3.7** Express each of the following quantities using scientific notation and the most appropriate SI unit prefixes.

	Quantity	Scientific notation	SI unit with prefixes
(a)	0.0005 kg		
(b)	562 m		
(c)	43 000 J		
(d)	5 678 345 Pa		
(e)	6473 V		
(f)	0.006 MJ		
(g)	0.000000005 m		
(h)	0.156 s		
(i)	2 400 000 000 000 000 km		
(j)	64 000 000 A		

- 1.2.3.8** Submultiples of units may be expressed using a prefix. Which one of the following lists the prefixes in decreasing order of magnitude?

- (A) Milli-, centi-, nano-, micro-.
- (B) Centi-, micro-, milli-, nano-.
- (C) Milli-, micro-, centi-, nano.
- (D) Centi-, milli-, micro-, nano-.

Uncertainty and error in measurement

1.2.6 Describe and give examples of random and systematic errors. © IBO 2007

1.2.8 Explain how the effects of random errors may be reduced. © IBO 2007

Note that 1.2.6 and 1.2.8 are combined and questions carry 1.2.6 numbers.

1.2.6.1 Describe, and give five examples of a random error.

1.2.6.2 Explain four ways of reducing random errors.

1.2.6.3 Describe, and give and five examples of a systematic error.

1.2.6.4 Explain four ways of reducing systematic errors.

1.2.6.5 Both random and systematic errors are present in the measurement of a particular quantity in an experiment. What changes, if any, would repeated measurements of this quantity have on the random and systematic errors?

- (A) Both would be reduced.
- (B) Random would be reduced, systematic would be unchanged.
- (C) Random would be unchanged, systematic would be reduced.
- (D) Both would be unchanged.

1.2.7 Distinguish between precision and accuracy. © IBO 2007

1.2.7.1

(a) Define the accuracy of a measurement.

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(b) How is the accuracy of a measurement indicated?

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1.2.7.2

(a) Define the precision of a measurement.

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(b) How is the precision of a measurement indicated?

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1.2.7.3 Two readings taken during an experiment were $X = 5.00 \pm 0.2$ and $Y = 5.0 \pm 0.02$.

Which choice best describes the characteristics of these two measurements?

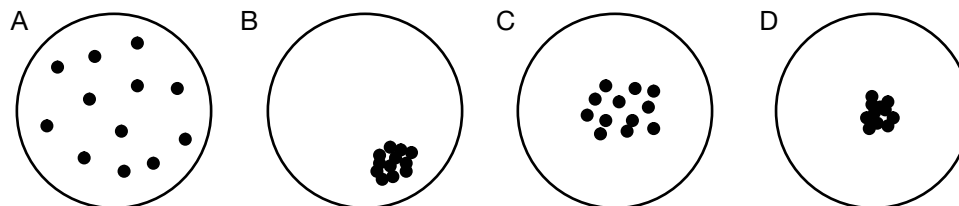
- (A) X has high accuracy while Y has high precision.
- (B) X has high accuracy while Y has low precision.
- (C) X has low accuracy while Y has high precision.
- (D) X has low accuracy while Y has low precision.

1.2.7.4 A meter has a zero reading of 0.5. Which statement about readings taken on this meter is correct?

- (A) Neither the precision nor the accuracy of the reading will be affected.
- (B) Both the precision nor the accuracy of the reading will be affected.
- (C) The precision will be affected but not the accuracy.
- (D) The accuracy will be affected but not the precision.

Use the following information to answer the next FOUR questions.

Four archers shoot arrows at a target. The object of the exercise is to hit the target in the centre. The diagrams below illustrate where the arrows hit.



1.2.7.5 Which archer was the least accurate and least precise?

- (A) A
- (B) B
- (C) C
- (D) D

1.2.7.6 Which archer was precise but not accurate?

- (A) A
- (B) B
- (C) C
- (D) D

1.2.7.7 Which archer was accurate and precise?

- (A) A
- (B) B
- (C) C
- (D) D

1.2.7.8 Compare the accuracy and the precision of the archer you have not yet chosen with the other three archers.

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1.2.7.9 The reading of a constant force is made four times by a student. The readings are 2.532, 2.535, 2.534 and 2.532.

The student averages these readings but does not take into account the zero error on the force balance. The average measurement of the force is:

- (A) Both precise and accurate.
- (B) Precise but not accurate.
- (C) Accurate but not precise.
- (D) Neither accurate nor precise.

1.2.9 Calculate quantities and results of calculations to the appropriate number of significant figures. © IBO 2007

1.2.9.1 State the number of significant figures in each of the measurements in the table.

1.2.9.2 Express each of the numbers in the table in scientific notation to two significant figures.

	Measurement	Number of significant figures	In scientific notation to two significant figures
(a)	0.0060		
(b)	0.0061		
(c)	1.0060		
(d)	1.0061		
(e)	1 000 000 000		
(f)	1 780 000 004		
(g)	1 856 000 000.0		
(h)	462.52		
(i)	0.6200		
(j)	4086		

1.2.9.3 Complete each of the following calculations giving your answers in the appropriate number of significant figures.

- (a) $4.62 + 8.9561 + 5.9 =$
- (b) $0.005 + 0.46 + 1.09 =$
- (c) $46.9 \times 12.4 \times 5.6 =$
- (d) $0.62 \times 9.2 \times 1.04 =$
- (e) $9.76 - 4.5 - 0.64 =$
- (f) $106 - 463 - 230.6 =$
- (g) Calculate the area of a square with sides 5.6 cm.
- (h) Calculate the volume of a cube with sides equal to 1.56 cm.
- (i) $(6.4 + 5.92 - 4.3) \div 2.25 =$
- (j) $\sqrt{9600 \times 1.25 \div 0.25} =$

1.2.9.4 The mass of a body is measured to be 0.400 kg and its acceleration to be 2 m s^{-2} . The net force on the body, expressed to the correct number of significant figures is:

- (A) 0.8 N
- (B) 0.80 N
- (C) 1 N
- (D) 1.0 N

1.2.9.5 A student hypothesised that F and A may be related by an expression of the form $F = aA$ where a is a constant. In order to test this suggestion, the data shown below are used. The uncertainties in the measurements of F and A are not shown.

$F \text{ (kg m s}^{-2}\text{)}$	$A \text{ (m}^2\text{)}$	$F/A \text{ (???)}$
12.04	8.60	???
18.23	11.8	
23.91	17.1	
31.58	23.6	
44.14	32.2	

(a) What are the correct units for F/A ?

- (A) $\text{kg m}^3 \text{ s}^{-2}$
- (B) $\text{kg m}^{-1} \text{ s}^{-2}$
- (C) $\text{kg m}^{-2} \text{ s}^{-2}$
- (D) $\text{kg m}^{-3} \text{ s}^{-2}$

(b) Calculate the magnitude of F/A to the correct number of significant figures for the value of $F = 23.91$.

- (A) 1.39
- (B) 1.398
- (C) 1.4
- (D) 1.40

(c) Evaluate the student's hypothesis.

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1.2.9.6 An object has an acceleration of 3.5 m s^{-2} . Which of the following gives the change in the speed of the object after 4.00 s to the correct number of significant digits?

- (A) 14 m s^{-1}
- (B) 14.0 m s^{-1}
- (C) 14.00 m s^{-1}
- (D) 14.000 m s^{-1}

Uncertainties in calculated results

1.2.10 State uncertainties as absolute, fractional and percentage uncertainties. © IBO 2007

1.2.10.1 Define the following terms.

(a) Limit of reading of a measuring instrument.

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(b) Maximum degree of uncertainty of a measuring instrument.

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(c) Absolute error.

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(d) Fractional or relative uncertainty.

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(e) Percentage uncertainty.

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(f) Percentage discrepancy.

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1.2.11 Determine the uncertainties in results. © IBO 2007

1.2.11.1 A student rolls a ball across a tabletop a distance of 1.00 m. This measurement has a 2% error associated with it. She measures the time the ball takes to roll this distance with a 5% error. She uses these measurements to calculate the average speed of the ball as it rolled.

What is the error associated with the speed calculation?

- (A) 2%
- (B) 3%
- (C) 5%
- (D) 7%

1.2.11.2 The kinetic energy of a moving object is calculated using the formula $KE = \frac{1}{2}mv^2$. The mass of an object was measured with a 4% uncertainty and its velocity with a 3% uncertainty.

What will be the uncertainty in its calculated kinetic energy?

- (A) 1%
- (B) 7%
- (C) 10%
- (D) 11%

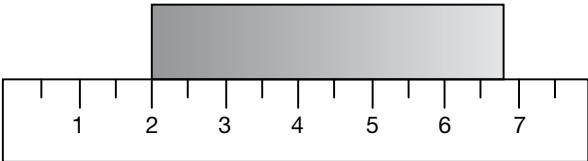
- 1.2.11.3** Three variables are related according to the equation $X = YZ^3$. In an experiment, students measured X with an uncertainty of 4% and Y with an uncertainty of 5%. They then used these values to calculate a value for Z . The uncertainty with the value for Z would be:
- (A) 1%
 - (B) 3%
 - (C) 9%
 - (D) 19%
- 1.2.11.4** The mass of the Earth is 5.974×10^{24} kg. What is the uncertainty associated with this measurement?
- (A) 0.0005
 - (B) 0.0005 kg
 - (C) 0.0005×10^{24}
 - (D) 0.0005×10^{24} kg
- 1.2.11.5** If $X = 35 \pm 0.5$ m and $Y = 15 \pm 0.7$ m, then which is the best answer for $3X - 2Y$?
- (A) 75 ± 0.1
 - (B) 75 ± 1
 - (C) 75 ± 3
 - (D) 75 ± 7
- 1.2.11.6** The result of a calculation is $0.678901 \mu\text{m}$ with an absolute error of $\pm 0.0006 \mu\text{m}$. How should this result be stated?
- (A) $0.678901 \pm 0.0006 \mu\text{m}$
 - (B) $0.6789 \pm 0.0006 \mu\text{m}$
 - (C) 678.9 ± 0.6 nm
 - (D) 678.901 ± 0.0006 nm
- 1.2.11.7** A student measured the current flowing through a 5Ω resistor with a constant potential difference across it. He obtained the following readings from repeated measurements.
1.65 A 1.54 A 1.72 A 1.67 A 1.48 A 1.53 A 1.66 A 1.81 A 1.73 A 1.14 A 1.69 A
- (a) What was the limit of reading of the meter used?
 - (b) What was the absolute error in each reading?
 - (c) What was the fractional error in the first reading?
 - (d) What was the percentage error in the second reading?
 - (e) What is the greatest deviation of any reading from the mean reading?
 - (f) What current and uncertainty should he report?
- 1.2.11.8** A student measured the angle of inclination of a ramp used in an experiment as $37^\circ \pm 2^\circ$. In his calculations he had to use the sine of this angle. How would he record this?
-
- 1.2.11.9** How should the volume of a cube with sides 4.5 ± 0.1 cm be reported?
-

1.2.11.10 If $T^2 = 46.5 \pm 0.4$, what is an appropriate value for T ?

1.2.11.11 If $X = 18 \pm 0.5$ and $Y = 9.0 \pm 0.4$, find appropriate values, including errors, for:

- (a) $X + Y$
- (b) $X - Y$
- (c) $X + 2Y$
- (d) $2X - 3Y$
- (e) $X \times Y$
- (f) $X \div Y$
- (g) $\sqrt{XY}$
- (h) XY^3

1.2.11.12 Consider the diagram of an object next to a centimetre rule.



- (a) What is the limit of reading of the rule?
- (b) What will be the uncertainty of the measurement?
- (c) What is the length of the figure, including error?
- (d) What is the relative error?
- (e) What is the percentage error?

Uncertainties in graphs

1.2.12 Identify uncertainties as error bars in graphs. © IBO 2007

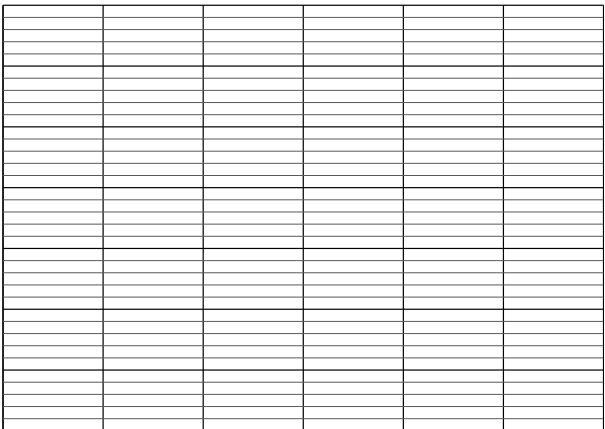
1.2.13 State random uncertainty as an uncertainty range and represent it graphically as an ‘error bar’. © IBO 2007

Note that 1.2.12 and 1.2.13 are combined and questions carry 1.2.12 numbers.

1.2.12.1 The table shows information about the force applied to a spring and the extension it causes.

Force $\pm 5 \text{ N}$	50	100	150	200	250	300
Extension $\pm 0.5 \text{ cm}$	5.5	12.0	16.0	21.0	26.0	31.5

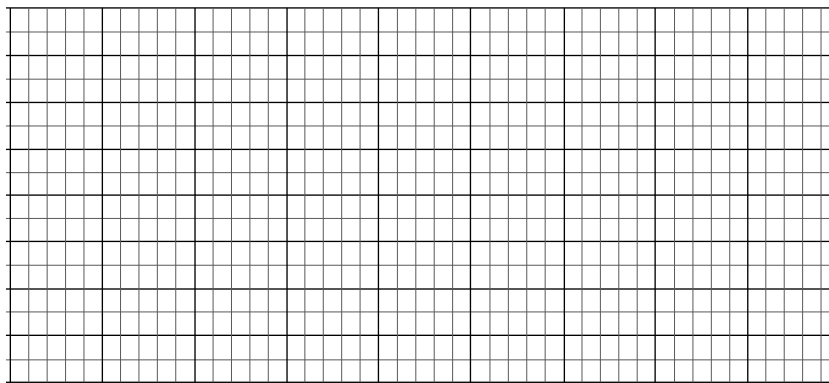
Graph this information using appropriate error bars on the grid.



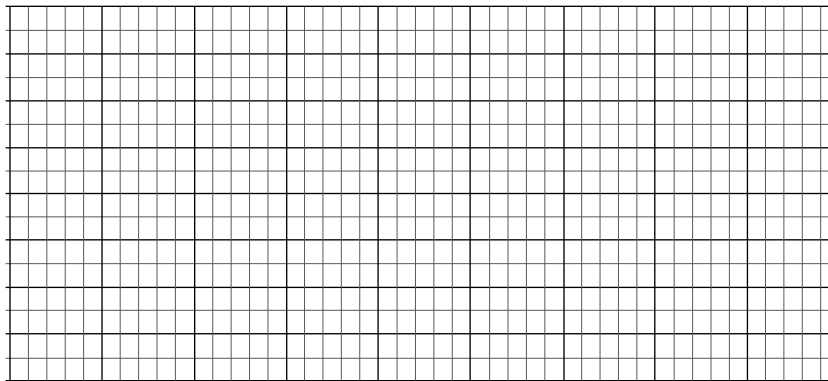
1.2.12.2

- (a) The table shows the average times it took an object to fall from rest through various distances. Graph this information using appropriate error bars on the grid below.

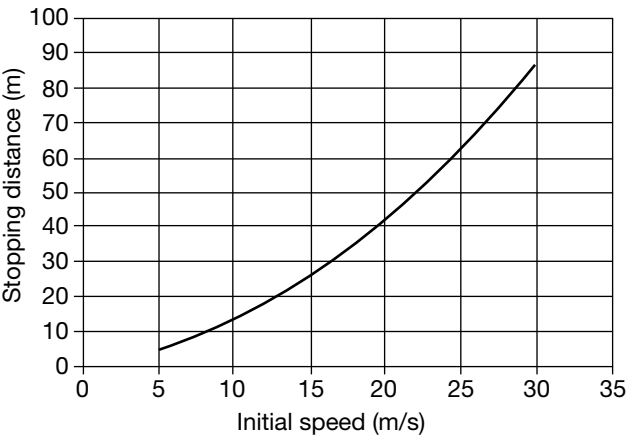
Distance fallen (± 0.05 m)	Time to fall (± 0.05 s)	(Time to fall) ²	Absolute error in T^2
3.0	1.0		
4.0	1.2		
5.0	1.3		
6.0	1.4		
7.0	1.5		
8.0	1.6		



- (b) Complete the third column of the table to the appropriate number of significant figures, including inserting the absolute uncertainty in these calculations.
- (c) Construct a graph of distance against time squared (T^2), including error bars.



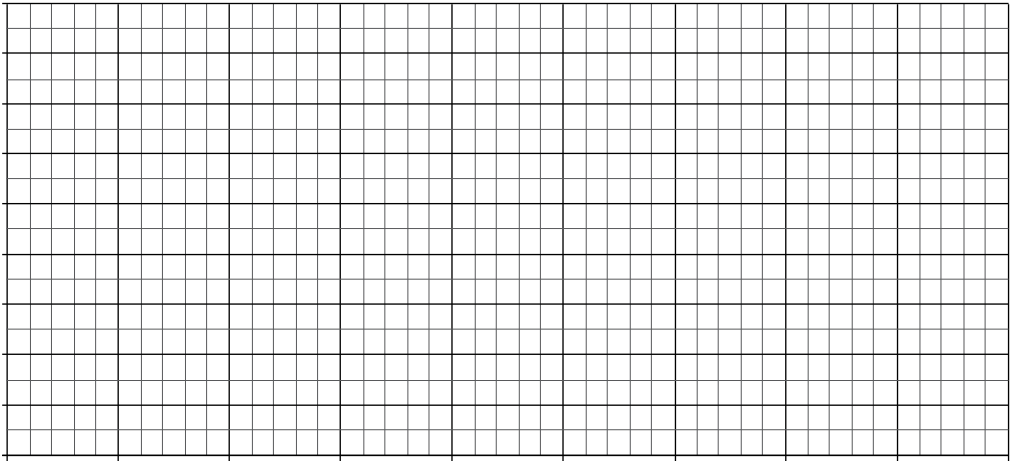
1.2.12.3 In an experiment to study how far a car moved as it stopped from different speeds, a driver travelled along a straight road at a constant speed v . At a particular point he applied the brakes to stop the car in as short a distance as possible. The total distance, D , travelled by the car while stopping was measured for various values of v . A graph of the results is shown.



- (a) Explain why the stopping distance is not able to be calculated from the equation $D = bv + c$.
-
-
- (b) The table shows the results of the experiment. Note that uncertainty values are not included. A column has been included for the values of D/v . Complete this column, including the units for D/v in the column header.

Initial speed v (m s ⁻¹)	Stopping distance D (m)	D/v
5.0	4.50	
10	13.0	
15	25.5	
20	42.0	
25	62.5	
30	87.0	

- (c) Construct a graph showing the relationship between D/v and v .



- (d) (i) Use your graph in (c) to determine the intercept on the D/v axis.
 (ii) Use the graph to determine the gradient of the best-fit line.

(e) Using your answers to (d) deduce the equation for D in terms of v .

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(f) (i) Use the graph supplied above to predict the stopping distance for an initial speed of 17.5 m s^{-1} .

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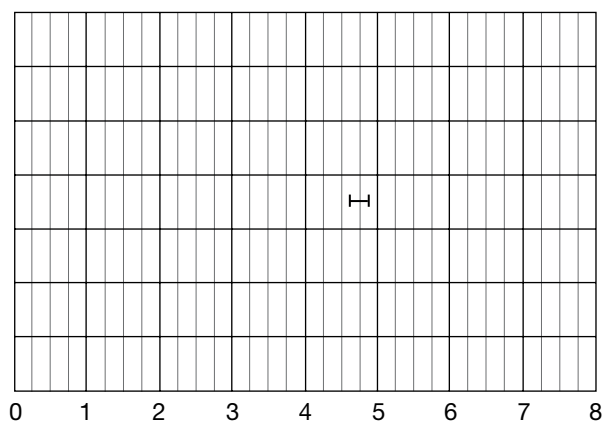
(ii) Use your answer to (e) to calculate the stopping distance for an initial speed of 17.5 m s^{-1} .

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(ii) Briefly discuss your answers to (i) and (ii).

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1.2.12.4 The grid shows one data point and its associated error bar on a graph. The y-axis is not shown.

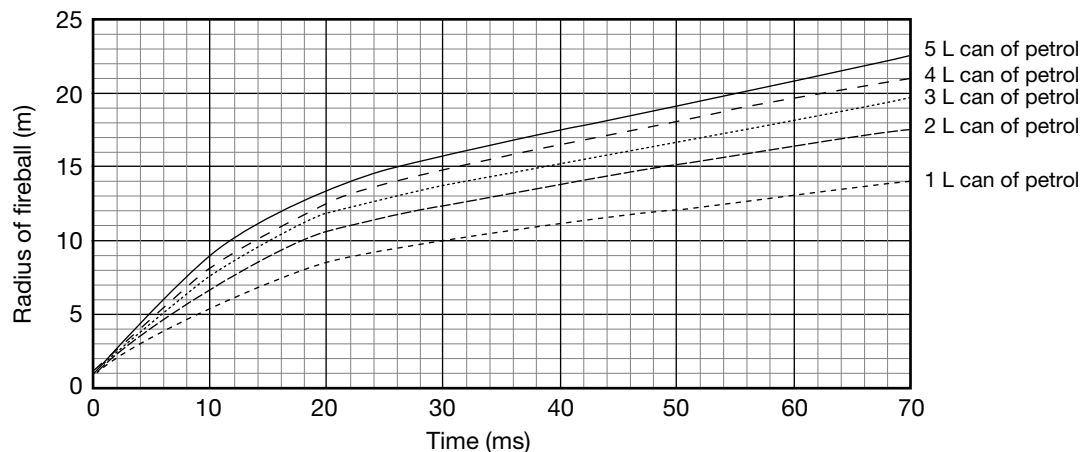


Which of the following is the best statement of the x-value of the data point, with its uncertainty?

- (A) 3.5 ± 0.5
 (B) 4.5 ± 0.2
 (C) 4.75 ± 0.1
 (D) 4.75 ± 0.25

1.2.12.5 A circular fireball forms when a fire burns, causing an explosion within a confined space. Knowing the speed with which these fireballs can spread is important to firefighters. In an experiment to try to predict this speed, a series of controlled experiments was carried out in which known volumes of petrol in sealed containers was ignited.

The radius R of the fireball produced in each explosion was measured as a function of time t . The results for five different volumes of petroleum are shown plotted.



- (a) The researchers made the hypothesis that, for a given volume of petrol, the radius R of the fireball would be directly proportional to the time t after the explosion. Discuss whether or not the data supports this hypothesis.

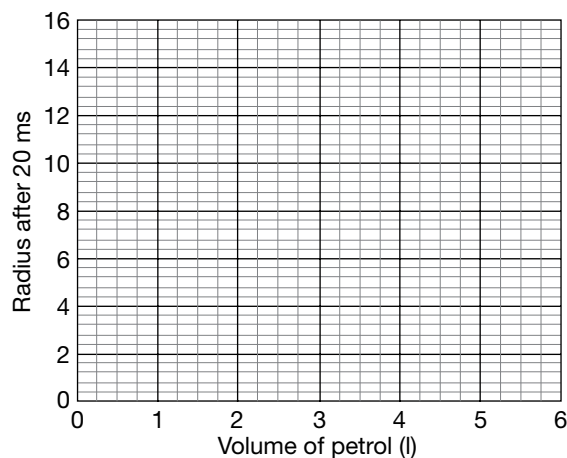
- (b) Another hypothesis is that the radius of the fireball at any particular time is proportional to the initial volume of the petrol.

To test this hypothesis, plot the radius R of the fireball 20 ms after the explosion against the initial volume V of petrol causing the fireball on the axes provided.

- (c) Put error bars on your plot points assuming that the volume has an uncertainty of ± 0.5 L.

- (d) Draw the line of best fit for the data points.

- (e) Explain whether the data supports the hypothesis that R is proportional to V .



- (f) Analysis shows that the relation between the radius R , energy E released and time t is given by $R^5 = Et^2$. Using the data for the 2 L petrol can from the initial graph, calculate the missing values in the table.

Time (ms)	(Time) ² (ms) ²	Radius (m)	(Radius) ⁵ (m ⁵)	$E = R^5/t^2$
0				
10				
20				
30				
40				
50				
60				
70				

- (g) Discuss whether or not this data supports the statement, explaining any discrepancies in your data.

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- (h) Assume that the error in measuring the radius of the fireball is ± 1.0 m. Calculate the error in the R^5 calculation at 10 ms.

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- (i) Express the reading at 10 ms for R^5 with its error.

- (j) Considering this error, does the reading at 10 ms also support the statement? Justify your answer.

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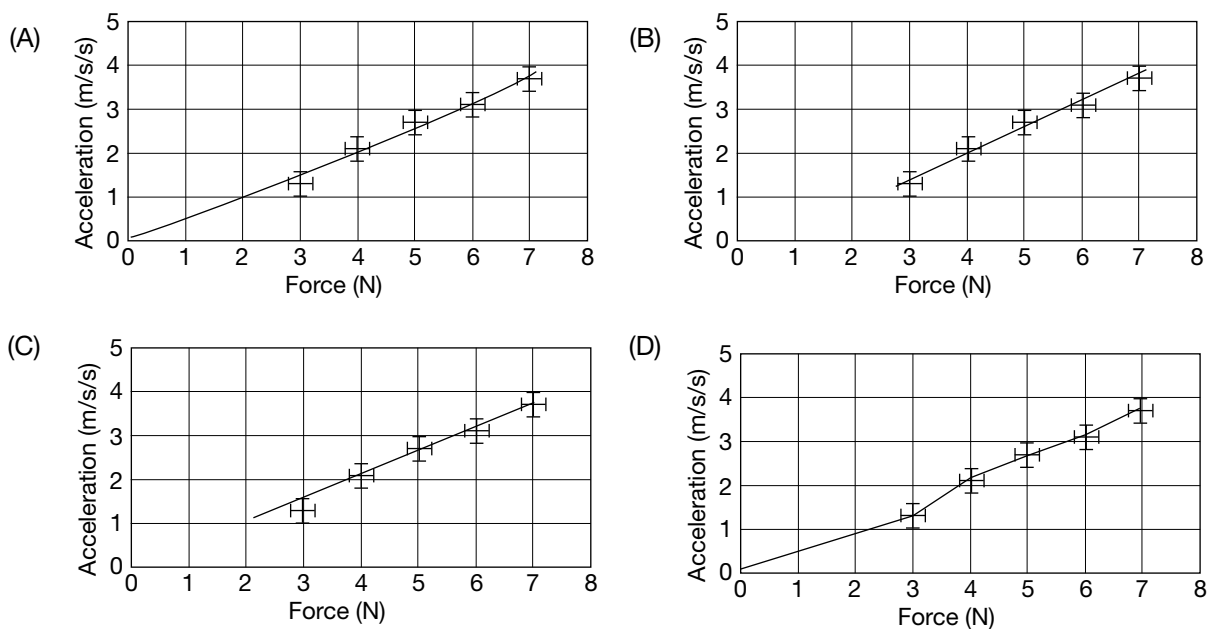
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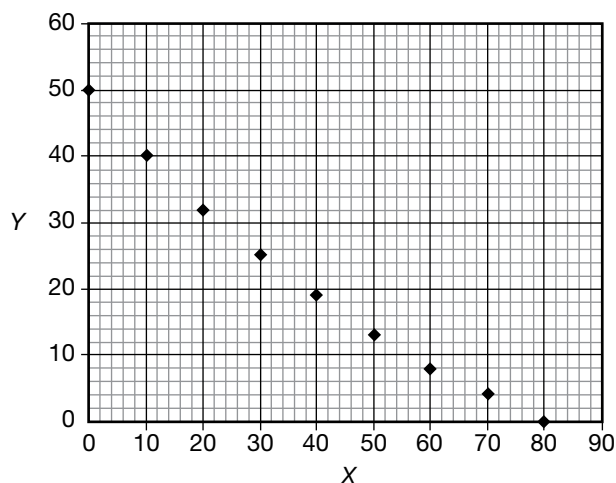
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- 1.2.12.6** Values of the force acting on an object of constant mass and the acceleration produced by that force are plotted on each graph below. Error bars for each point have been included. Which of the following shows the best-fit line for the plotted points?



1.2.14 Determine the uncertainties in the gradient and intercepts of a straight-line graph. © IBO 2007

- 1.2.14.1** The experimental readings for an experiment are shown on the graph grid below. The uncertainty in the measurement of variable Y is ± 2 . The uncertainty in the measurement of variable X was negligible.



- Draw in the error bars for Y measurements.
- Draw in a line of best fit for these readings.
- Estimate the value of Y when $X = 15$.
- Determine the gradient of the line of best fit at the point where $X = 20$.

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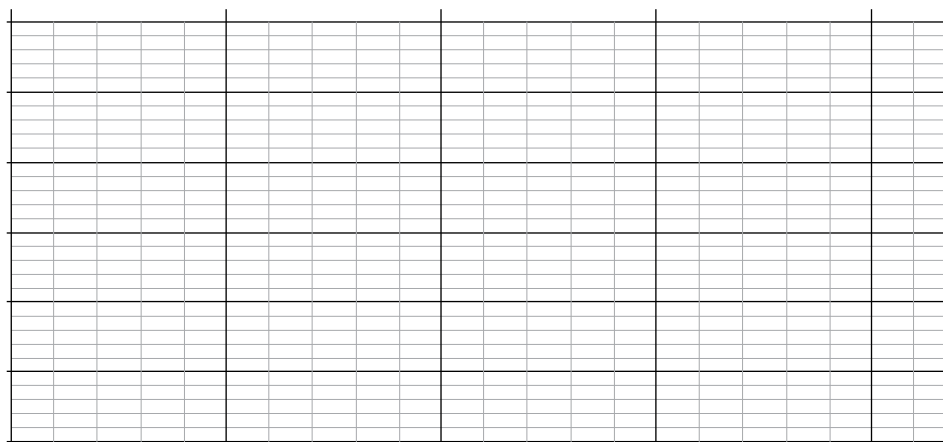
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1.2.14.2

- (a) The table shows the acceleration produced when a variable force acts on a body of constant mass. From Newton's laws of motion, we know that these two variables are connected by the equation $F = ma + b$, where b represents the frictional force acting. Graph this information using appropriate error bars on the grid below.

Applied force ((N)	5.0	7.5	10.0	12.5	15.0	17.5	20.0
Acceleration produced (m s^{-2})	0.11	0.20	0.26	0.33	0.40	0.47	0.55



- (b) Use your graph to determine the mass of the object.

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- (c) Add two additional lines to your graph (code them differently) to represent the error associated with the trend line for this data.

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- (d) Again, using your graph, determine the frictional force acting on the object and calculate the appropriate error for your answer.

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This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

1.3 Vectors and scalars. © IBO 2007

1.3.1 Distinguish between vector and scalar quantities, and give examples of each. © IBO 2007

1.3.1.1 Distinguish between a scalar and a vector quantity.

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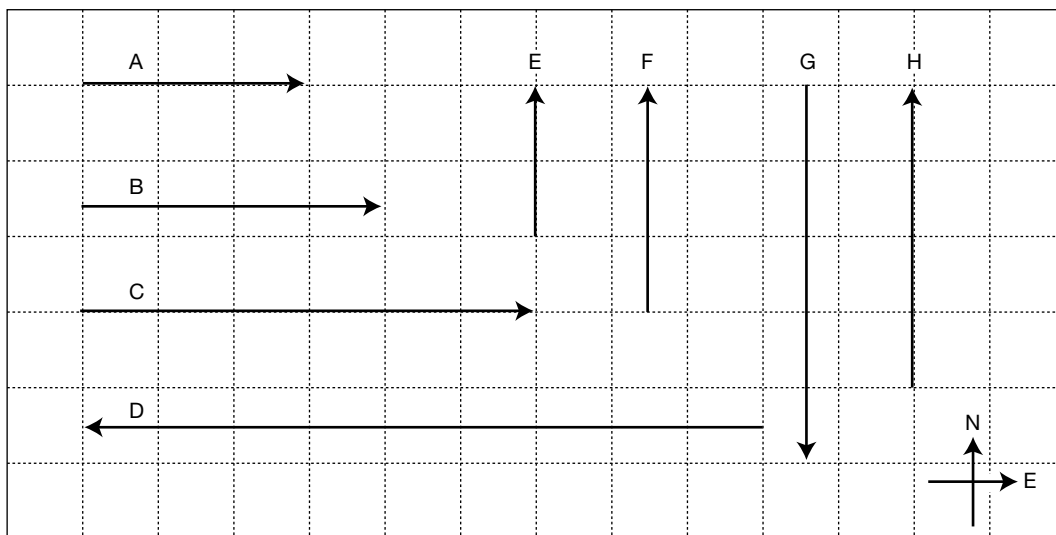
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1.3.1.2 Complete the table to list scalar and vector quantities and the main units we use to measure them.

Scalar quantities			Vector quantities		
Quantity	Symbol	Unit	Quantity	Symbol	Unit

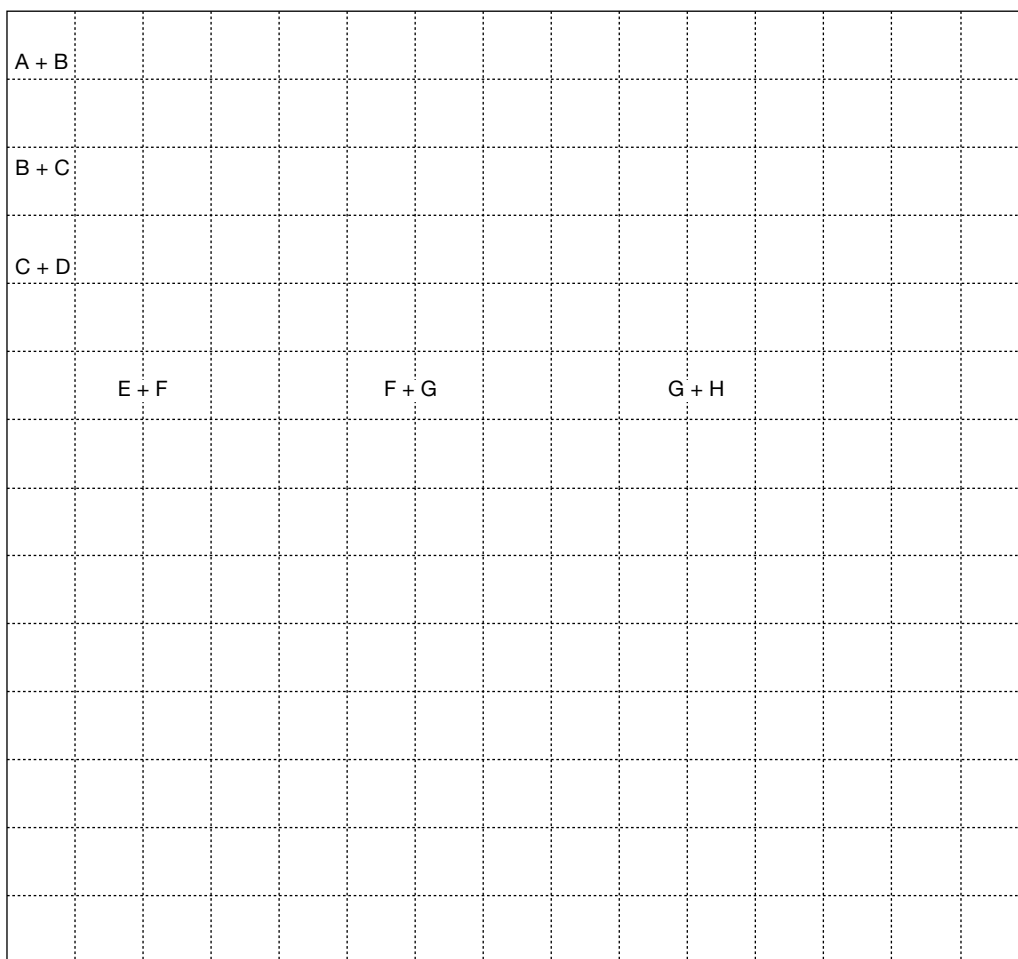
1.3.2 Determine the sum or difference of two vectors by a graphical method. © IBO 2007

1.3.2.1 The diagram represents several displacement vectors.



Scale: 1 grid space = 5 metres

(a) Draw diagrams to show the following vector additions.



(b) Draw diagrams to show the following vector subtractions.

A 10x10 grid with dashed lines. The first three rows are labeled A-B, B-C, and C-D on the left. The fourth row is labeled E-F, F-G, and G-H across its width.

1.3.2.2 Vector X is 12 N right, vector Y is 8 N left, and vector Z is 17 N left. What is:

- (a) $X + Y + Z?$
- (b) $X - Y - Z?$
- (c) $Y - Z + X?$

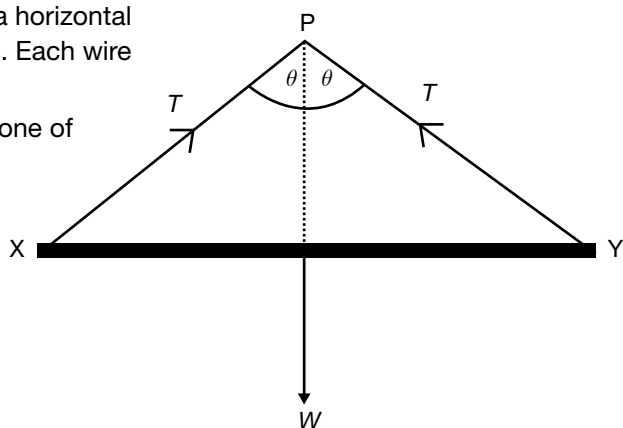
1.3.2.3 A vector of magnitude 6 units is added to a second vector of magnitude 5 units. What are the maximum and minimum possible values for this addition? Justify your answer.

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- 1.3.2.4** A uniform metal bar XY of weight W is hung from a horizontal support at point P by two wires of negligible mass. Each wire makes an angle θ with the vertical.

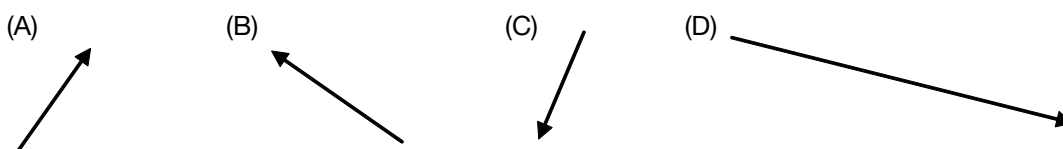


- Which of the following is equal to the tension T in one of the wires?
- (A) $W \cos \theta$
 (B) $W \div 2 \cos \theta$
 (C) $W \sin \theta$
 (D) $W \div 2 \sin \theta$

- 1.3.2.5** The diagram show two vectors, P and Q.

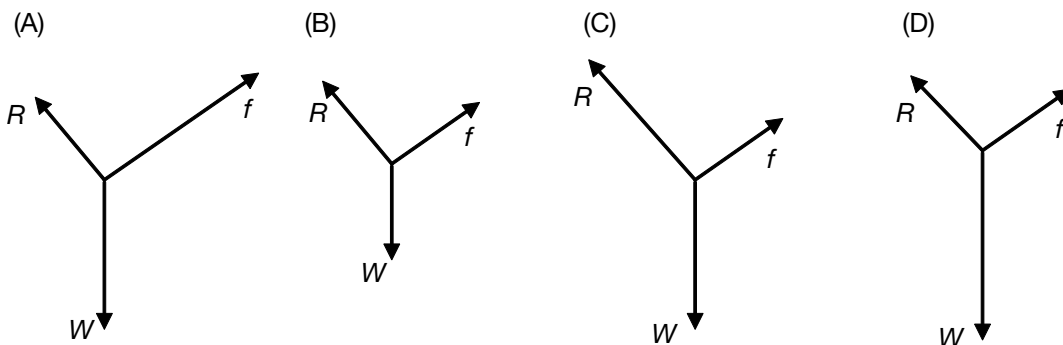


Which choice best shows the vector addition $P + Q$?

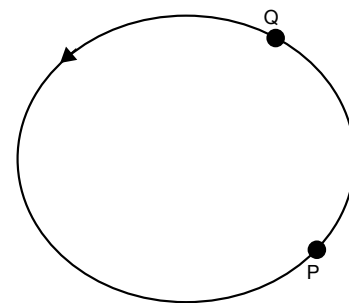


- 1.3.2.6** A block of weight W is sliding at constant speed down an incline against a frictional force of f . The normal reaction between the surface and the block is R .

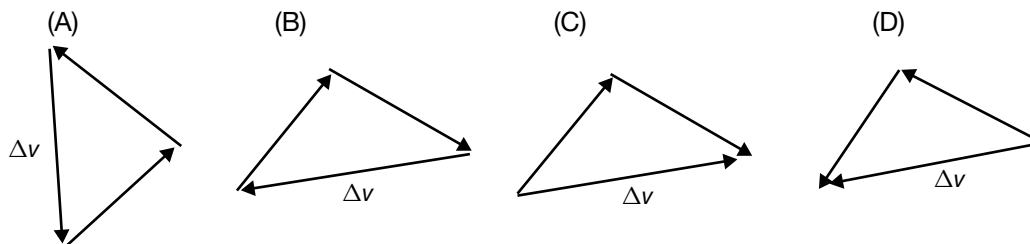
Which diagram best represents the forces acting on the block?



- 1.3.2.7** A point mass is moving in a horizontal circle with a constant speed of $v \text{ m s}^{-1}$. At one particular time, the mass is at P. A short time later, the mass is at Q, as shown.



Which diagram best shows how to determine the change in velocity, Δv , of the mass between P and Q?



- 1.3.2.8** An object moves from P to Q, 4.0 m east. It then moves from Q to R, 3.0 m north. From R it moves 6.0 m west to S. Calculate its final displacement.

- 1.3.2.9** X walks 5 km east from O, turns, and then walks 7 km on a bearing of 345° . Calculate its final displacement.

- 1.3.2.10** A car drives 270 km east from X to Y in 3 hours, and then a further 360 km south to Z in the next 4 hours.

(a) Calculate its average speed.

(b) Calculate its average velocity.

(c) If it drove directly from X to Z at the same average speed, how long would it take?

1.3.2.11 An car travels north at 60 kph for 2 hours. It then travels west for 5 hours at 80 kph.

(a) Calculate its average speed.

.....

.....

(b) Calculate its average velocity.

.....

.....

1.3.2.12 By drawing a vector diagram, find the resultant displacement of a car, which drives 10 km N, then 15 km E, then 7 km SW, then 4 km N.

.....

.....

1.3.2.13 Three towns, X, Y and Z are connected by straight roads. XY is 6 km, YZ is 4 km, and XZ is 5 km.

(a) If Y is north of X, where is Z relative to X?

.....

.....

(b) Where is X relative to Z?

.....

.....

1.3.2.14 A car travels 50 km east and then north for 30 km. It then travels 25 km on a bearing of 030° . Calculate its final displacement.

.....

.....

1.3.2.15 A vector of magnitude 4 units is added to a vector of magnitude 9 units. What are the maximum and minimum values for the resultant?

.....

.....

1.3.3 Resolve vectors into perpendicular components along chosen axes. © IBO 2007

1.3.3.1 The resultant vector (R) in each diagram represents the initial velocity of a projectile. Use the diagrams and the additional information to find the missing quantities in the table.

	Diagram	Angle	Resultant	Horizontal component	Vertical Component	Answers
(a)		30°	6	A	B	A = B =
(b)		45°	C	10.6	D	C = D =
(c)		E	10	0	F	E = F =
(d)		120°	G	H	21.65	G = H =
(e)		I	J	12.95	12.5	I = J =
(f)		K	7.5	L	2.57	K = L =
(g)		$36^\circ 25'$	M	N	14.65	M = N =
(h)		O	72.05	42.65	P	O = P =
(i)		$15^\circ 12'$	Q	0.66	R	Q = R =
(j)		S	236	T	143.7	S = T =

1.3.3.2 A vector is 15 cm long. It points 30° east of north. It has two components at right angles to each other. One of these is in the direction 30° west of north.

(a) Calculate the direction of the other.

.....

.....

.....

(b) Calculate its magnitude.

.....

.....

1.3.3.3 A man pushes on a 40 kg hand lawnmower with a force of 300 N. The handle makes an angle of 35° with the ground.

(a) Find the magnitude of the force pushing the mower forwards.

.....

.....

.....

(b) Determine the reaction force of the ground on the mower.

.....

.....

.....

1.3.3.4 A 20 kg block rests on a board inclined at 25° to the benchtop. If the frictional force between the block and the board is 2.8 N:

(a) Calculate the net force on the block down the incline.

.....

.....

.....

(b) Calculate the normal reaction between the block and the board.

.....

.....

.....

DOT POINT

ANSWERS

[illegible]

CORE 1 Physics and Physical Measurement

1.1.1.1 The order of magnitude of a number is the power of ten closest to that number.

1.1.1.2

- (a) 10^1
- (b) 10^{-2} (Remember that order of magnitude is found by firstly expressing the number in scientific notation and then finding its logarithm (base 10).) The log, rounded to the nearest whole number gives the power of 10 for the order of magnitude.
- (c) 10^1
- (d) 10^{-2}
- (e) 10^2
- (f) 10^4
- (g) 10^2
- (h) 10^0
- (i) 10^{-5}
- (j) 10^{-4}
- (k) 10^7
- (l) 10^5
- (m) 10^3
- (n) 10^{-7}
- (o) 10^9
- (p) 10^{10}
- (q) 10^3
- (r) 10^3
- (s) 10^4
- (t) 10^{-2}

1.1.1.3 When numbers are really large or really small or when you are asked for an 'indication' of size rather than an exact measurement, an order of magnitude is often more appropriate than an exact answer. When precise measurements are required or when numbers are in 'normal' ranges, an exact answer is usually more appropriate.

1.1.2.1

- (a) 10^{50}
- (b) 10^{25}
- (c) 10^3
- (d) 10^{-1}
- (e) 10^0
- (f) 10^{-27}
- (g) 10^{-30}
- (h) 10^{50}
- (i) 10^{14}
- (j) 10^{11}
- (k) 10^7
- (l) 10^0
- (m) 10^{-2}
- (n) 10^{-13}
- (o) 10^{18}
- (p) 10^{15}
- (q) 10^9

- (r) 10^7
- (s) 10^5
- (t) 10^{-6}
- (u) 10^{-14} or 10^{-15}

- 1.1.3.1**
- (a) 10^4 times larger
 - (b) 10^2 times larger
 - (c) 10^1 times larger
 - (d) 10^2 times larger
 - (e) 10^{11} times larger
 - (f) 10^2 times larger
 - (g) 10^3 times larger
 - (i) 10^6 times larger
 - (j) 10^2 times smaller
 - (k) 10^6 times smaller
 - (l) 10^{13} times smaller

1.1.4.1 Note that answers will vary as most of these things are not of standard size. If you are within 10% of the estimate given here, count yourself as 'close enough'.

- (a) 65 10^2
- (b) 205 10^2
- (c) 200 grams 10^2
- (d) 3×10^{11} 10^{11}
- (e) 300 mL 10^2
- (f) 10 L 10^1
- (g) 20 mm³ 10^1
- (h) 9000 10^4
- (i) $15 \times 8 \times 2$ $10^1 \times 10^1 \times 10^0$
- (j) 7×10^{24} 10^{25}
- (k) 0.65 10^0
- (l) 30 cm 10^1
- (m) 12 cm 10^1
- (n) 600 g 10^2
- (o) 1×10^{13} 10^{13}
- (p) 2×10^2 10^9
- (q) 400 g 10^3
- (r) 380 000 km 10^6
- (s) 1×10^{12} km 10^{12}
- (t) 3.5×10^{-5} 10^{-4}

1.2.1.1 A fundamental quantity is one which is defined and has no dependence on any other quantity.

1.2.1.2 A derived quantity can be a defined quantity, but it will be dependent on two or more fundamental quantities, or a combination of one unit (for example area = distance²).

1.2.1.3 Density is defined as the mass per unit volume of a substance and is measured in kg m⁻³ which is a combination of the fundamental units for mass (the kg) and distance (m). Note that the quantity volume is also a derived quantity, depending on distance cubed.

1.2.1.4 SI refers to Standard International units, a system of units for quantities used (almost) worldwide so that communication between scientists is faster, easier and better understood.

1.2.1.5

	Fundamental quantity	SI unit for quantity	SI symbol for unit
(a)	Mass	kilogram	kg
(b)	Length	metre	m
(c)	Time	second	s
(d)	Electric current	ampere	A
(e)	Amount of a substance	mole	mol
(f)	Temperature	kelvin	K
(g)	Luminosity	candela	Cd

1.2.1.6

	Derived quantity	SI unit for quantity	SI symbol for unit	Dependence on fundamental units
(a)	Acceleration	metres per second per second	m s^{-2}	m s^{-2}
(b)	Charge	coulomb	C	A s
(c)	Electric field strength	volts per metre	E	V m^{-1}
(d)	Electrical potential	volt	V	$\text{kg m}^2 \text{s}^{-3} \text{A}^{-1}$
(e)	Electrical resistance	ohm	Ω	$\text{kg m}^2 \text{s}^{-3} \text{A}^{-2}$
(f)	Energy	joule	J	$\text{kg m}^2 \text{s}^{-2}$
(g)	Force	newton	N	kg m s^{-2}
(h)	Frequency	hertz	Hz	s^{-1}
(i)	Heat capacity	calorie	C	J K^{-1}
(j)	Magnetic field strength	tesla	T	$\text{kg s}^{-2} \text{A}^{-1}$
(k)	Magnetic flux	weber	Φ	$\text{kg m}^2 \text{s}^{-2} \text{A}^{-1}$
(l)	Momentum	kilogram metres per second	kg m s^{-1}	kg m s^{-1}
(m)	Power	watt	W	$\text{kg m}^2 \text{s}^{-3}$
(n)	Pressure	pascal	Pa	$\text{kg m}^{-1} \text{s}^{-2}$
(o)	Radioactivity	becquerel	Bq	–
(p)	Specific heat capacity	calorie	c	$\text{m}^2 \text{s}^{-2} \text{K}^{-1}$
(q)	Velocity	metres per second	m s^{-1}	m s^{-1}

1.2.1.7 C

1.2.1.8 B

1.2.3.1

Multiple	Prefix	Symbol
10^{24}	yotta	Y
10^{21}	zeta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^2	hecto	h
10^1	deca	da
10^{-1}	deci	d
10^{-1}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

- 1.2.3.2**
- (a) 7.2×10^{-1} kg
 - (b) 4.5×10^3 kg
 - (c) 1.056×10^{-6} m
 - (d) 4.26×10^{16} m
 - (e) 3.6×10^{10} m

- 1.2.3.3**
- (a) 7.78×10^3 m s⁻¹
 - (b) 4.5×10^{-5} m³
 - (c) 4.0×10^5 Pa
 - (d) 3.0×10^6 m³
 - (e) 2.5×10^6 J

1.2.3.4 2.25×10^4 m

1.2.3.5 kg⁻¹ m³ s⁻²

1.2.3.6 2.36×10^9 J or 2.36 GJ

1.2.3.7

	Quantity	Scientific notation	SI unit with prefixes
(a)	0.0005 kg	5×10^{-4} kg	50 mkg (actually, grams)
(b)	562 m	5.62×10^2 m	5.62 hm
(c)	43 000 J	4.3×10^4 J	43 kJ
(d)	5 678 345 Pa	5.68×10^6 Pa	5.68 MPa
(e)	6473 V	6.47×10^3 V	6.47 kV
(f)	0.006 MJ	6.0×10^{-3} MJ	6.0 kJ
(g)	0.000000005 m	5.0×10^{-9} m	5.0 nm
(h)	0.156 s	1.56×10^{-1} s	1.56 ds
(i)	2 400 000 000 000 000 km	2.4×10^{15} km	2.4 Pm
(j)	64 000 000 A	6.4×10^7 A	64 MA

1.2.3.8 D

1.2.6.1 Random errors are caused by uncertainties in measuring instruments, mistakes made by people and uncontrolled external factors. They include things like ambient temperature variations, misreading scales, parallax error, vibrations affecting equipment, air currents, incorrect calculations, use of incorrect formulas, variations in the characteristics of the data being collected.

1.2.6.2 Random error can be reduced by taking multiple readings and using average values. This will produce a measurement which will be closer to the true value than many of the individual readings.

Random error can also be reduced by using more accurate measuring instruments and by having consistent experimental procedures. Both of these strategies will reduce the magnitude of any variation in readings.

Random error is also reduced by controlling or eliminating all other factors which might influence the measurement. This will also reduce the variation in repeated measurements.

1.2.6.3 Systematic errors cause experimental results to be spread around a value which is not necessarily the accepted value. They include incorrectly calibrated instruments, poor reaction time of the experimenter, consistent parallax error, poor quality instruments, and instrument zero errors.

1.2.6.4 It is important to realise that systematic errors cannot be reduced by taking multiple readings because they are often caused by errors in the instruments and/or operators themselves. Systematic errors can be reduced by using the most accurate equipment available, by having different operators check the readings, by ensuring that readings are taken carefully and correctly and by ensuring there is no zero error in an instrument.

1.2.6.5 B

- 1.2.7.1**
- (a) The accuracy of a measurement is an indication of how close that measurement is to the accepted value of that measure.
 - (b) Accuracy is indicated by the inclusion of relative or percentage errors when reporting the measurement.

- 1.2.7.2**
- (a) The precision of a measurement is an indication of the agreement between repeated measurements made in the same way.
 - (b) Precision is indicated by the absolute error in a measurement.

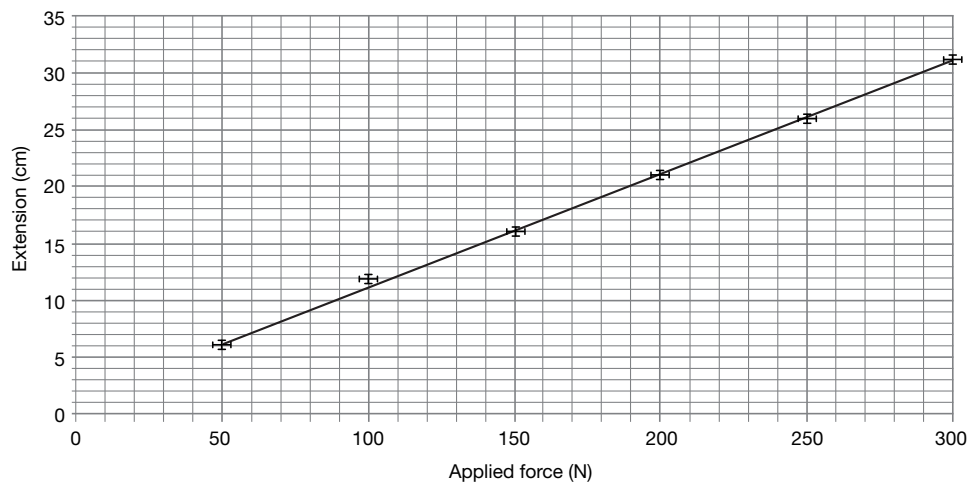
- 1.2.7.3 A
- 1.2.7.4 D
- 1.2.7.5 A
- 1.2.7.6 B
- 1.2.7.7 D
- 1.2.7.8 Archer C is more accurate than archer A or B but not as accurate as archer D. Archer C is more precise than archer A but less precise than either archer B or D.
- 1.2.7.9 B
- 1.2.9.1 and 1.2.9.2

	Measurement	Number of significant figures	In scientific notation to two significant figures
(a)	0.0060	2	6.0×10^{-3}
(b)	0.0061	2	6.1×10^{-3}
(c)	1.0060	5	1.0
(d)	1.0061	5	1.0
(e)	1 000 000 000	1	1.0×10^9
(f)	1 780 000 004	10	1.8×10^9
(g)	1 856 000 000.0	11	1.9×10^9
(h)	462.52	5	4.6×10^2
(i)	0.6200	4	6.2×10^{-1}
(j)	4086	4	4.1×10^3

- 1.2.9.3
- (a) 19
 - (b) 1.6
 - (c) 3300
 - (d) 5.9
 - (e) 4.6
 - (f) -588
 - (g) 32 cm^2
 - (h) 3.80 cm^3
 - (i) 3.6
 - (j) 220
- 1.2.9.4 C
- 1.2.9.5
- (a) B
 - (b) D
 - (c) The hypothesis is incorrect since further calculations show that the value of F/A for the readings is not constant.
- 1.2.9.6 A
- 1.2.10.1
- (a) The limit of reading of an instrument is defined as equal to the smallest scale division on the scale of the instrument.
 - (b) The maximum degree of uncertainty of an instrument is half the limit of reading of that instrument.
 - (c) Absolute error is the error associated with a measurement.
 - (d) Fractional uncertainty is equal to the ratio of the absolute uncertainty to the measurement.
 - (e) Percentage uncertainty is fractional uncertainty expressed as a percentage (i.e. fractional uncertainty $\times 100$).
 - (f) Percentage discrepancy is equal to the difference between an experimental result and an accepted value expressed as a percentage of the accepted value.
- 1.2.11.1 D
- 1.2.11.2 C
- 1.2.11.3 B
- 1.2.11.4 D

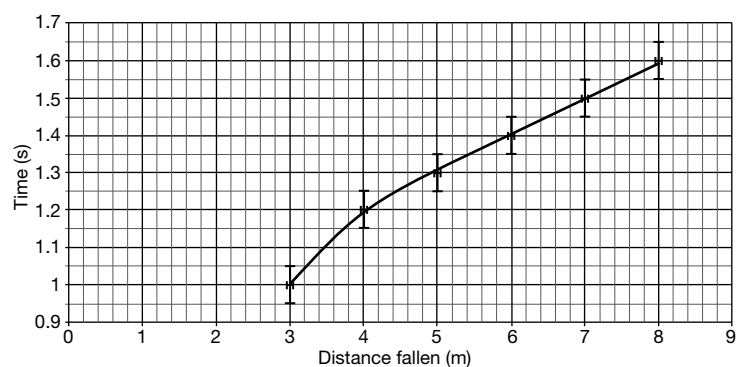
- 1.2.11.5** C
- 1.2.11.6** B
- 1.2.11.7** (a) 0.01 A
 (b) 0.005 A
 (c) $\pm 3 \times 10^{-3}$
 (d) ± 0.3
 (e) 0.17
 (f) 1.65 ± 0.2 A (largest residual is 0.17, reported as 0.2 since errors only reported to one significant figure). Note that the 1.14 reading should be ignored as an outlier due to random error.
- 1.2.11.8** 0.60 ± 0.03
- 1.2.11.9** $91.0 \pm 6.0 \text{ cm}^3$
- 1.2.11.10** 6.82 ± 0.2
- 1.2.11.11** (a) 27.0 ± 0.9
 (b) 9.0 ± 0.9
 (c) 36.0 ± 1 (Note: Uncertainties expressed to one significant figure only.)
 (d) 9.0 ± 2
 (e) 162 ± 10
 (f) 2.0 ± 0.1
 (g) 12.7 ± 5
 (h) $13\,000 \pm 2100$
- 1.2.11.12** (a) 0.5 cm
 (b) 0.25 cm
 (c) $4.8 \pm 0.2 \text{ cm}$
 (d) 0.04
 (e) 4%

1.2.12.1

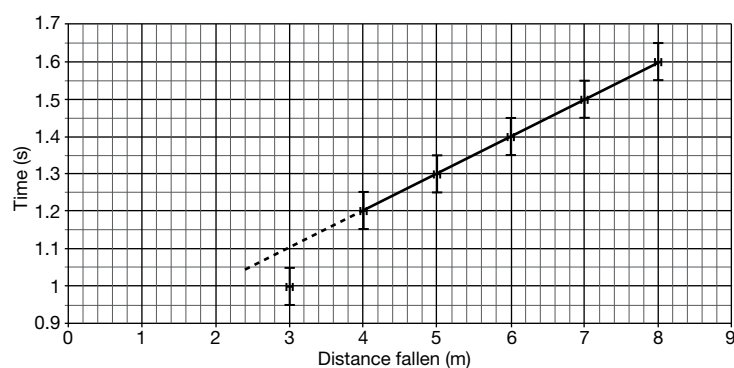


1.2.12.2

(a)



Note that if you don't know the mathematical relationship being tested in the experiment, it would be reasonable to regard the first plot point in this series of measures as a mistake caused by random error. In that case it would be ignored, and your graph would look like the following graph.

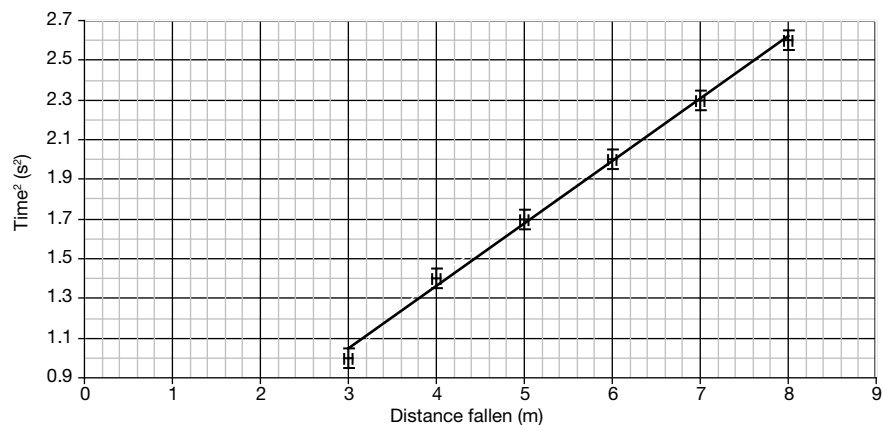


(b)

Distance fallen (± 0.05 m)	Time to fall (± 0.05 s)	(Time to fall) ²	Absolute error in T^2
3.0	1.0	1.0	0.1
4.0	1.2	1.4	0.1
5.0	1.3	1.7	0.1
6.0	1.4	2.0	0.1
7.0	1.5	2.3	0.1
8.0	1.6	2.6	0.2

Note that time is given to two significant figures only, so time squared can only be given to two significant figures.

(c)



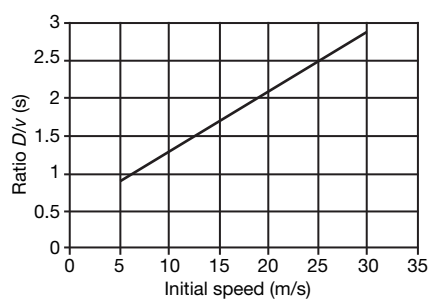
1.2.12.3

- (a) The equation $D = bv + c$ is the equation for a straight line. The graph is obviously not a straight line, so the equation would appear to be incorrect.

(b)

Initial speed v (m s^{-1})	Stopping distance D (m)	D/v (s)
5.0	4.50	0.90
10	13.0	1.3
15	25.5	1.7
20	42.0	2.1
25	62.5	2.5
30	87.0	2.9

(c)



- (d) (i) 0.5

(ii) Gradient = rise/run = $2.0/25 = 0.08$

- (e) From mathematical theory, for a straight line relationship, $y = mx + b$ where m = gradient, and b = y intercept therefore $D/v = 0.08v + 0.5$ or $D = 0.08v^2 + 0.5v$

- (f) (i) About 34 m

(ii) 33.25 m (should be reported as 33 m)

- (iii) The two values are in close agreement. The calculated value will be the more accurate and whether or not the estimate from the graph is acceptable depends on the relative errors associated with each measurement and these have not been calculated.

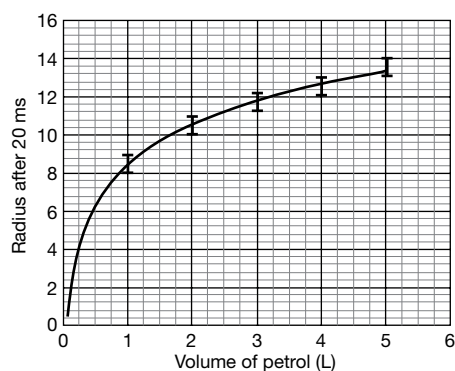
1.2.12.4

C

1.2.12.5

- (a) The data does not support the hypothesis as the graph is not a straight line and does not go through the origin. However, after 30 m s all graph lines are straight, so the relationship approaches being direct from 30 m s on (they all suit the equation $y = mx + b$).

(b), (c), (d) See diagram.



- (e) Again, the hypothesis is not supported because the graph is not a straight line through the origin.

- (f) Note that values in this table should be expressed to three significant figures only.

Time (ms)	(Time) ² (ms) ²	Radius (m)	(Radius) ⁵ (m ⁵)	$E = R^5/t^2$
0	0	0	0	–
10	100	6.75	14 000	140
20	400	10.5	128 000	320
30	900	12.25	276 000	307
40	1600	14.0	538 000	336
50	2500	15.0	759 000	304
60	3600	16.5	1 220 000	339
70	4900	17.5	1 640 000	335

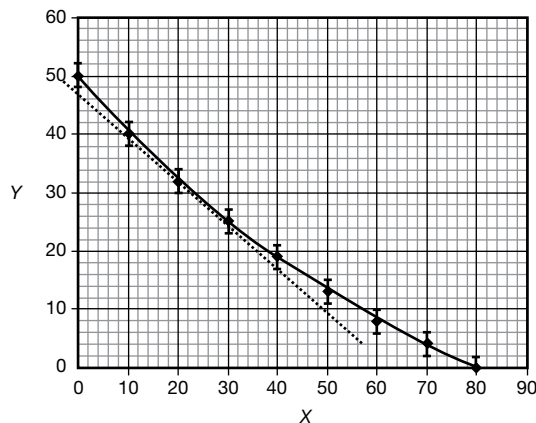
- (g) This statement would seem to hold except for the reading at 10 ms. Perhaps the reading at 10 ms is in error (an outlier), or perhaps the relationship is unstable until the fireball reaches a minimum size which is greater than 6.75 m radius.
- (h) 6.75 ± 0.6 means a relative error of 0.09 or 9%.
For R^5 this would be an error of ± 0.45 or 45%.
- (i) $14000 \pm 6300 \text{ m}^5$
- (j) The maximum and minimum values for R^5 at 10 ms are therefore 20 300 and 7700.
Taking the 5th root of these we get maximum and minimum values for R at 10 ms as 7.3 and 6.0.
These give R^5/t^2 values between 203 and 77 which do not approach the values from the other five readings.
Therefore the error does not allow the reading at 10 ms to support the statement.

1.2.12.6

B

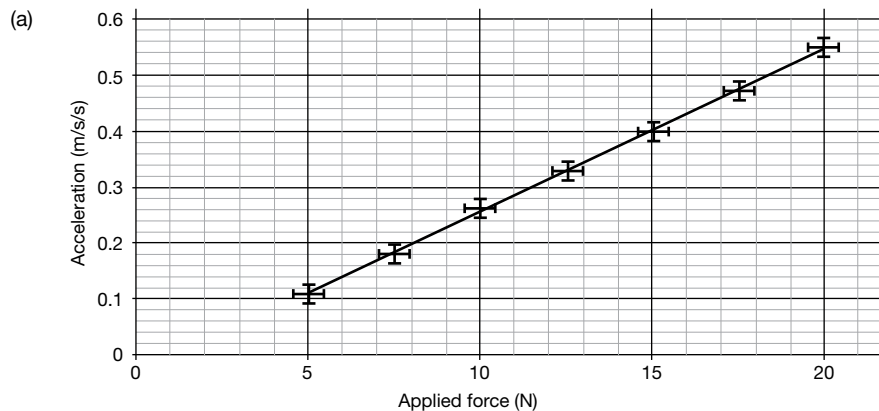
1.2.14.1

- (a) and (b) and (d) See graph.

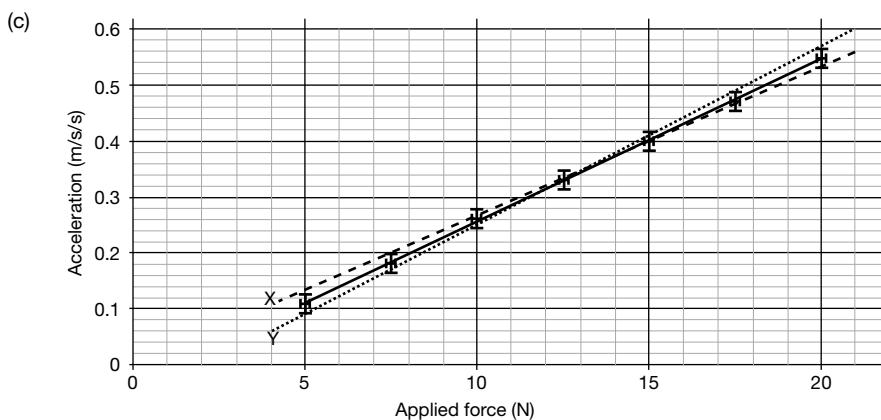


- (c) 36 ± 2
- (d) See above and gradient = fall/run = $36/48 = -0.75 \pm 0.2$

1.2.14.2

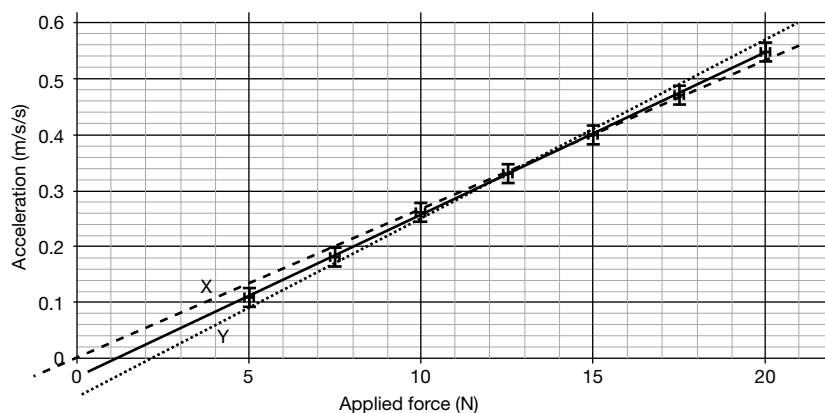


- (b) Given $F = ma$
then $m = F/a = \text{inverse gradient} = \text{run/rise} = 15/0.44 = 34.1 \text{ kg}$.
However, given that data is supplied only to two significant figures, answer should be given as 34 kg.



- (d) Extending your line of best fit back till it cuts the x-axis, we see the frictional force as about 1.2 N.

By extending both the X and Y trend error lines back until they cut the x-axis, we obtain the error and should report the friction as 1.2 ± 1 N.



For line X, $m = \text{run/rise} = 15/0.40 = 37.5$ kg, but report as 37 kg.

For line Y, $m = \text{run/rise} = 15/0.48 = 31.2$ kg but report as 31 kg.

Therefore, mass of object as determined from this data should be reported as 33 ± 3 kg.

1.3.1.1

Scalar quantities only require magnitude, vector quantities need magnitude and direction to fully define them.

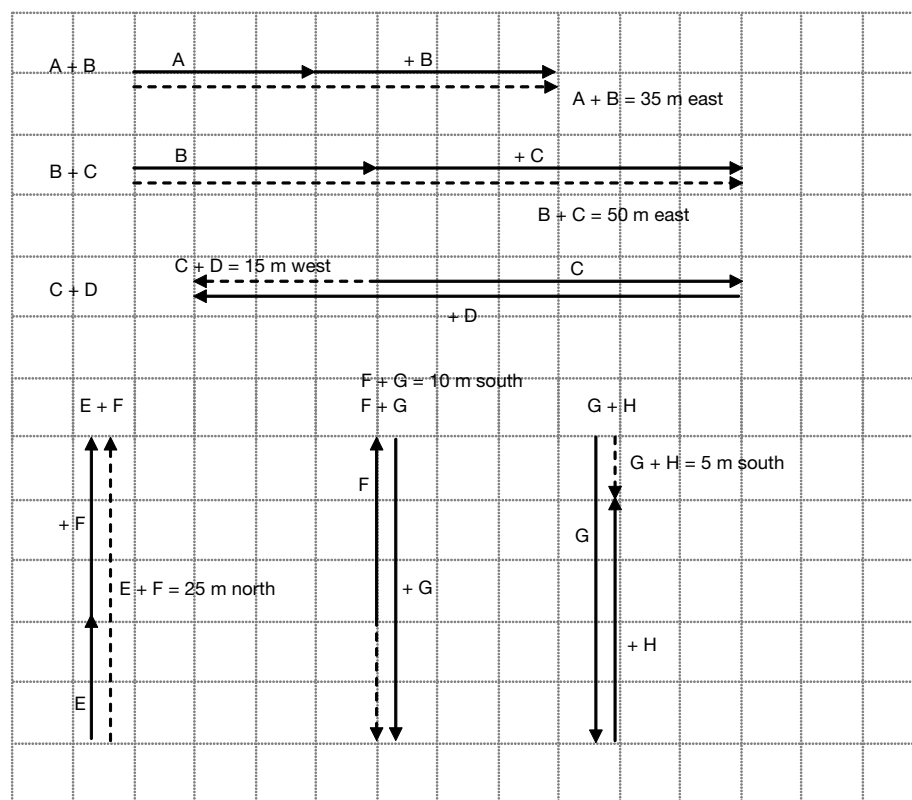
1.3.1.2

For example: Note that your table may include others – check with text or teacher if unsure.

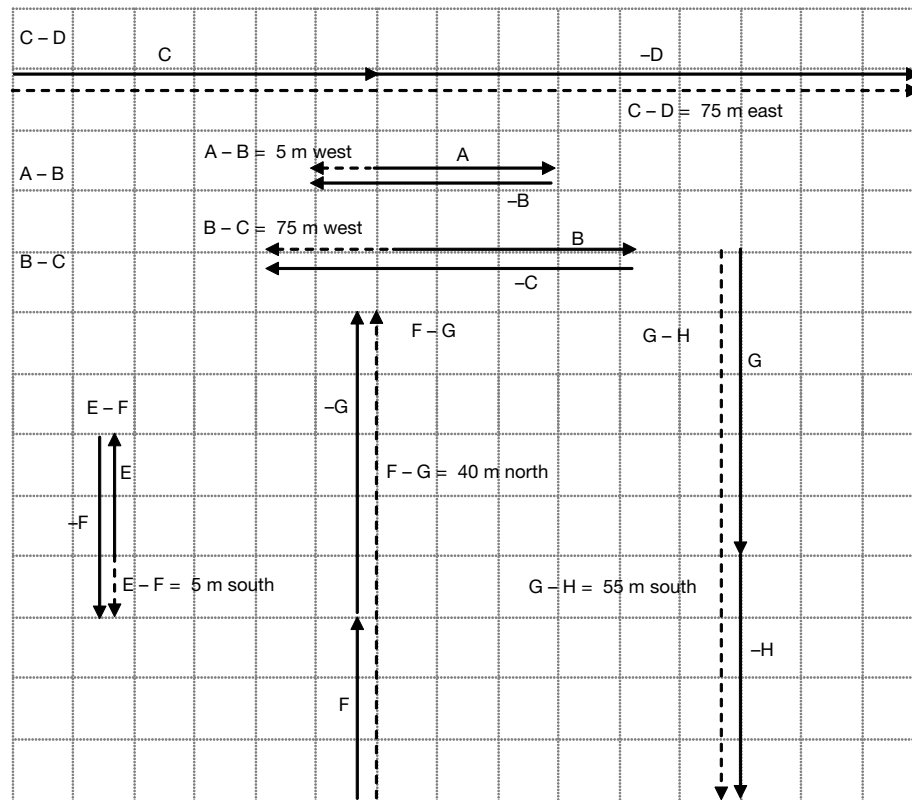
Scalar quantities			Vector quantities		
Quantity	Symbol	Unit	Quantity	Symbol	Unit
Mass	m	kilogram (kg)	Weight	W_F	newton (N)
Time	T	second (s)	Electric field	E	volts per metre ($V\ m^{-1}$)
Length	L	metre (m)	Magnetic field	B	tesla (T)
Electric charge	Q	coulomb (C)	Torque	τ	newton metre (N m)
Temperature	T	$^{\circ}C$	Displacement	r	metre (m)
Distance travelled	D	metre (m)	Velocity	v	metres per second ($m\ s^{-1}$)
Speed	Speed	metres per second ($m\ s^{-1}$)	Force	F	newton (N)
Energy	E	joules (J)	Acceleration	a	metres per second per second ($m\ s^{-2}$)
Work	W	joules (J)	Impulse	I	newton seconds (N s or $kg\ m\ s^{-1}$)
Power	P	watts (W)	Momentum	p	kilogram metres per second ($kg\ m\ s^{-1}$)

1.3.2.1

(a)



(b)



1.3.2.2

- (a) 13 left
- (b) 37 right
- (c) 21 right

- 1.3.2.3** Maximum value is 11 units (when both vectors act in the same direction). Minimum value is 1 unit (or -1 unit) when the vectors act directly in opposite directions.
- 1.3.2.4** D
- 1.3.2.5** A
- 1.3.2.6** C
- 1.3.2.7** D
- 1.3.2.8** 3.6 m b 326
- 1.3.2.9** 7.47 km b 025
- 1.3.2.10** (a) 90 kph
(b) 64.3 kph b 127
(c) 5 hours
- 1.3.2.11** (a) 74.3 kph
(b) 59.7 kph b 287
- 1.3.2.12** 13.5 km b 048
- 1.3.2.13** (a) b 041 or b 319
(b) b 229 or b 139
- 1.3.2.14** 81.1 km b 050
- 1.3.2.15** Maximum = 13 (add them).
Minimum = 5 (subtract them).
- 1.3.3.1** A = 5.2
B = 3.0
C = 15
D = 10.6
E = 90
F = 10
G = 25
H = 12.5
I = 136
J = 18
K = 110
L = 7.05
M = 18.2
N = 10.8
O = 144
P = 58
Q = 0.68
R = 0.18
S = 97.3
T = 187.2
- 1.3.3.2** (a) b 060
(b) 13 cm
- 1.3.3.3** (a) 245.7 N
(b) 654 N vertically upwards
- 1.3.3.4** (a) 80 N down the incline
(b) 177.6 N up, perpendicular to the board